TECHNICAL PROTOCOL

Comparison on Calibration of Multimeter

EURAMET Project No 1341

TÜBİTAK UME

(Rev. 6)
August 02, 2016

ULUSAL METROLOJİ ENSTİTÜSÜ
Gebze Yerleşkesi P.K. 54 41470 Gezbe Kocaeli T 262 679 50 00 F 0626 679 50 01 www.ume.tubitak.gov.tr

Contents

1. Introduction

During the 6th Meeting of the EURAMET FG FNMID, held in Istanbul (Turkey) in November 2013, it was decided to organize an intercomparison on multimeter calibration, in order to support the CMCs of NMIs in the CIPM KCDB.

During the EURAMET TC-EM meeting, which was held in MIRS, Ljubljana (Slovenia) on October 16-17, 2014, it was decided to announce the comparison to all TC-EM members asking for further participants. The comparison was proposed by UME and was registered as EURAMET Project No 1341.

UME is acting as the pilot institute. Thus, UME is responsible for providing the travelling standard, monitoring its performance during circulation, and the evaluation and reporting of the measurement results.

The scope of the comparison is calibration of 8½ digits multimeter for the following quantities:

- DC Voltage
- AC Voltage
- DC Current
- AC Current
- DC Resistance

The comparison will be carried out in accordance with the CCEM Guidelines for Planning, Organizing, Conducting and Reporting Key, Supplementary and Pilot Comparisons [1].

2. Travelling Standard

The travelling standard is an 8½ digit multimeter, Fluke 8508A Reference Multimeter (Figure 1), supplied by TÜBİTAK UME. This DMM was chosen for its high accuracy and stability in time on DC Voltage, AC voltage, DC current, AC current and resistance measurement functions. It can be remotely operated by means of an IEEE 488. The general specifications of 8508A are given in Table 1.

Front Panel

Rear Panel

Figure 1. Travelling standard is a Fluke 8508 Reference Multimeter

Table 1. The general specifications of 8508A Reference Multimeter

Power	Power supply 200 V to 240 V rms ±10 % @ 47 Hz to 63 Hz Consumption < 80 VA
Dimensions	Height 88 mm (3.5 inches) Width 427 mm (16.8 inches) Depth 487 mm (19.2 inches)
Weight	11.5 kg (25.5 lbs)
Environment Temperature	Operating 0 °C to 50 °C Storage -20 °C to 70 °C
Relative Humidity	Operating, 5 °C to 40 °C < 90 %rh Storage, 0 °C to 70 °C < 95 %rh
Warm Up Time	4 hours to full uncertainty specification
Measurement Ranges	DC Voltage: 200 mV, 2 V, 20 V, 200 V, 1000 V AC Voltage: 200 mV, 2 V, 20 V, 200 V, 1000 V (1 Hz to 1 MHz) DC Current: 200 µA, 2 mA, 20 mA, 200 mA, 2 A, 20 A AC Current: 200 µA, 2 mA, 20 mA, 200 mA, 2 A, 20 A (1 Hz to 100 kHz) Resistance: 2 Ω, 20 Ω, 200 Ω, 2 kΩ, 20 kΩ, 200 kΩ, 2 MΩ, 20 MΩ, 200 MΩ, 2 GΩ, 20 GΩ

3. Participant Laboratories

The pilot institute for this comparison is TÜBİTAK UME (Turkey). The contact details of the coordinator are given below:

Pilot Institute	**:**	TÜBİTAK Ulusal Metroloji Enstitüsü (UME)
Coordinator	**:**	Saliha TURHAN Tel: +90 262 679 50 00 Fax: +90 262 679 50 01 E-mail: saliha.turhan@tubitak.gov.tr

A list of all participating institutes and contact persons with their addresses is given in Annex 1.

4. Time Schedule

The time schedule for the supplementary comparison is given in the Table 2. The comparison will begin in March 2015 and is scheduled to be completed within 1 year. The circulation of travelling standard will be organized in loops of not more than 3 institutes in order to monitor the performance of the travelling standard. Each laboratory will have 2 weeks to carry out the measurements and transportation. Any deviation in the agreed plan should be approved by the pilot institute.

Table 2. Circulation Time Schedule

Acronym of Institute	Country	Starting Date	Time for measurement and transportation
UME	Turkey	02.03.2015	14 days
MBM	Montenegro	16.03.2015	14 days
IMBiH	Bosnia and Herzegovina	30.03.2015	14 days
UME	Turkey	13.04.2015	14 days
HMI/FER-PEL	Croatia	27.04.2015	14 days
INM	Romania	11.05.2015	14 days
CMI	Czech Republic	25.05.2015	14 days
UME	Turkey	08.06.2015	35 days
FTMC	Lithuania	13.07.2015	14 days
UME	Turkey	27.07.2015	35 days
IPQ	Portugal	31.08.2015	14 days
BoM	FYR Macedonia	14.09.2015	14 days
UME	Turkey	28.09.2015	28 days
AS METROSERT	Estonia	26.10.2015	14 days
GUM	Poland	09.11.2015	14 days
DPM	Albania	19.01.2016	27 days
UME	Turkey	15.02.2016	91 days
KMA	Kosovo	16.05.2016	14 days
NSAI NML	Ireland	20.06.2016	14 days
UME	Turkey	01.08.2016	14 days
QCC	United Arab Emirates (UAE)	15.08.2016	14 days
SASO	Kingdom of Saudi Arabia	29.08.2016	14 days
UME	Turkey	12.09.2016	14 days

5. Measurement Quantities and Points

The quantities to be measured are DC voltage, DC current, AC voltage, AC current and DC resistance. The measurement points for each quantities and the configuration of the travelling standard, Fluke 8508A, during the comparison measurements are given in Table 3.

Table 3. Measurement quantities & points and the configuration of Fluke 8508A

Quantity	Measurement Point	Range of 8508A	Settling Time of 8508A	Configuration of 8508A
DC Voltage	100 mV	200 mV	5 min	Resolution 7 Filter ON Fast OFF Front Input
	10 V	20 V	5 min	
	100 V	200 V	5 min	
	1000 V	1000 V	10 min	
DC Current	100 µA	200 µA	5 min	Resolution 7 Filter ON Fast OFF Front Input
	10 mA	20 mA	5 min	
	1 A	2 A	30 min	
AC Voltage	100 mV @ 55 Hz†	200 mV	5 min	Resolution 6 Transfer ON AC Coupled RMS Filter 100 Hz (†RMS Filter 40 Hz @ 55 Hz) Front Input
	100 mV @ 1 kHz		5 min	
	10 V @ 55 Hz†	20 V	5 min	
	10 V @ 1 kHz		5 min	
	10 V @ 100 kHz		5 min	
	100 V @ 55 Hz†	200 V	5 min	
	100 V @ 1 kHz		5 min	
AC Current	10 mA @ 300 Hz	20 mA	5 min	Resolution 6 AC Coupled RMS Filter 100 Hz Front Input
	10 mA @ 1 kHz		5 min	
	1 A @ 300 Hz	2 A	30 min	
	1 A @ 1 kHz		30 min	
DC Resistance	10 Ω	20 Ω	5 min	TrueΩ (‡ Normal Ω for 1 MΩ) Resolution 7 4-Wire Low Current OFF (‡ Low Current ON) Filter ON Fast OFF Front Input
	10 kΩ	20 kΩ	5 min	
	10 kΩ‡		5 min	
	1 MΩ‡	2 MΩ	5 min	

6. Calculation of the Comparison Reference Value

The Comparison Reference Value (CRV) for each measurement point will be calculated as the weighted mean of the corrected results of the institutes due to the time dependence of the travelling standard, which will be calculated using the results of the pilot institute. Any result identified as inconsistent will be excluded from the determination of the CRV.

7. Transportation of Travelling Standard

The travelling standard will be transported using an ATA Carnet for custom clearance where possible.

It is the responsibility of each laboratory that the ATA carnet is used properly. At each transport the carnet must be presented to the customs on leaving the country and upon the arrival in the country of destination.

The travelling standard is packed in a transport case of size (79.4 x 61.5 x 44.4) cm and a total weight of 26 kg. The transport case can easily be opened for customs inspection.

7.1. Transport Case

The pilot institute must be informed of receipt of the standard and its dispatch to the next laboratory using the forms provided. The checklist (Annex 2), the receipt form (Annex 3) and dispatch form (Annex 4) will be sent to participants by e-mail.

On receipt of the case, the device should be unpacked carefully and checked for any damage. The functioning of the 8508A shall be controlled by initiating the “Self Test” (See details in page 3.36 of 8508A Users Manual [2])

1. Allow the Multimeter to warm-up under power at least 10 minutes.
2. Press the CLEAR key, select “Pwr Up Dflt” to restore the power up default configuration and display the DCV menu.
3. Press the “Test” key and select “Std” to initiate a selftest.

The contents of the transport case also should be checked. The receipt form (Annex 3) should be completed and sent to the pilot institute by e-mail.

Before sending the case out, the checklist form should be carefully followed in order to include all the material for the next laboratory. The dispatch form (Annex 4) should be completed and sent to the pilot institute by e-mail.

The content of the transport case is given below:

1. Fluke 8508A Reference Multimeter (Serial No: 969656608)*
2. Power cord
3. 4 wire shorting device
4. ATA Carnet

* The multimeter will be supplied without input leads.

7.2. Failure of Travelling Standard

In case of any damage or malfunction of the travelling standard, the pilot institute shall be informed immediately. The comparison will be carried out after the travelling standard is repaired.

7.3. Financial aspects

Each participant institute is responsible for its own costs for the measurements, transportation to the next participant, insurance of the shipment to the next participant and any customs charges as well as any damage that may occur within its country.

The overall costs for the organisation of the comparison are covered by the pilot institute. The pilot institute has no insurance for any loss or damage of the travelling standard.

8. Measurement Instructions

8.1. Before the Measurements

Ensure that the mains voltage setting is applicable to the local supply, and check that the instrument is functioning correctly.

It should be allowed to stabilize in a temperature and humidity controlled environment for at least 24 hours before commencing measurements.

8.2. Measurement Conditions

1. The standard ambient conditions for measurement are ;

   Temperature : (23 ± 1) °C

   Relative humidity : (45 ± 10) %rh
2. The non-volatile adjustment of Reference Multimeter is not allowed during the comparison measurements. Therefore the rear panel calibration keyswitch is set to DISABLE position and the CAL legend is not shown on the main display.
3. The reference multimeter should be allowed to warm-up under power at least 4 hours.
4. The reference multimeter should be used in the configurations given in Table 3.
5. The front input terminals of Reference Multimeter must be used for all measurements.
6. The settling time of the reference multimeter must be considered.
7. A single earth connection must be used in the measurement setup to avoid ground loops.
8. Before making DC measurements, for each point, a “zero” should be applied and “Null Zero” should be executed.
9. Any standard method may be used for calibrating the reference multimeter.
10. The measurement points required by the comparison protocol are given in Table 3.
11. The measurement result shall be reported as the relative error of the Reference Multimeter and calculated by;

$$\text{Error} = \frac{\text{Measured Value (reading of Travelling Standard)} - \text{Applied Value}}{\text{Applied Value}}$$

9. Measurement Uncertainty

The uncertainty of measurement must be calculated according to the JCGM 100 “Guide to the Expression of Uncertainty in Measurement” [3] for the coverage probability of approximately 95 %.

All contributions to the measurement uncertainty should be listed in the report submitted by each participant. In uncertainty evaluations, the effective degrees of freedom and the coverage factor should be reported.

Even though the contributions to the uncertainty are specific to the measurement method used, it may be useful to consider the list of uncertainty sources given below.

1. The measurement standard used e.g.:
    a. Multifunction calibrator (for all or some of the measurements)
    b. Reference voltage standard (for DC voltage measurements)
    c. Standard resistor (for resistance measurements)
    d. DC current shunt (for DC current measurements)
    e. AC/DC transfer standard (for AC voltage measurements)
    f. AC/DC current shunt (for AC current measurements)
2. Thermal electromotive force (emf) (for low DC voltage)
3. Drift of the reference standard (drift due to time, temperature, loading etc.)
4. Finite resolution of the travelling standard (DMM)
5. Repeatability

10. Reporting of Results

The results should be communicated to the pilot institute within 30 days of completing the measurements.

The measurement results should be reported in the format given in Annex 5 and should contain (for each measurement) at least:

- Details of participating institute,
- The date of the measurements,
- A detailed description of the method used,
- The measurement standards used in the comparison measurements,
- The environmental conditions during the measurements,
- Results of measurement (the relative error of the travelling standard and associated expanded uncertainty),
- A detailed uncertainty budget.

11. Final Report of the Comparison

The pilot institute is responsible for the preparation of a report on the comparison.

After the results have been received from the participants, a first draft (Draft A) of the report will be prepared by the pilot institute within 4 months and will be sent to the participants. This draft will be confidential to the participants.

The participants will have one month to send their comments on Draft A. On the basis of the comments received, the pilot institute will prepare the second draft (Draft B), where the withdrawn results will not appear or, in case of correction, the original and the corrected results, with the given explanation, are reported.

Draft B will be submitted to the EURAMET TC-EM and, after approval, will become the Final Report. The Final Report will form the basis for the publication of results.

12. References

[1] CCEM Guidelines for Planning, Organizing, Conducting and Reporting Key, Supplementary and Pilot Comparisons, 2007

[2] Users Manual of Fluke 8508A, Rev. 6, 3/13, July 2002 (available on the Fluke website: http://download.flukecal.com/secure/8508A___umeng0600.pdf?nvb=20141106132929&nva=20141106134429&token=020b92b6195b5e710f30d)

[3] Evaluation of measurement data - Guide to the Expression of Uncertainty in Measurement (GUM), JCGM 100, First edition, September 2008 (available on the BIPM website: http://www.bipm.org/utils/common/documents/jcgm/JCGM_100_2008_E.pdf)

Annex 1: Participating Institutes

No	Country	Acronym of Institute	Name of Institute	Shipping Address	Contact Person	ATA Carnet
1.	Albania	DPM	General Directorate of Metrology	Autostrada Tiranë - Durrës, km 8 (Rruga dytësore) Tiranë Albania	Yljon Seferi yljon.seferi@dpm.gov.al Tel: +355 4 2233 174	Yes
2.	Bosnia and Herzegovina	IMBiH	Institute of Metrology of Bosnia and Herzegovina	Institute of Metrology of Bosnia and Herzegovina Augusta Brauna 2 BA-71000 Sarajevo, Bosnia and Herzegovina	Vladimir Milojevic vladimir.milojevic@met.gov.ba Tel: +387 33 568 901	Yes
3.	Czech Republic	CMI	Czech Metrology Institute	Czech Metrology Institute Laboratory of DC/LF Electrical Quantities Okruzni 31 638 00 BRNO, Czech Republic	Jiri Streit jstreit@cmi.cz Tel: +420 545 555 208	Yes
4.	Croatia	HMI/FER-PEL	Faculty of Electrical Engineering and Computing - Primary Electromagnetic Laboratory	University of Zagreb, Faculty of Electrical Engineering and Computing Unska 3, HR-10000 Zagreb, Croatia	Damir Ilic damir.ilic@fer.hr Tel: +385 1 612 9753	Yes
5.	Estonia	AS METROSERT	Central Office of Metrology	National Standards Laboratory for Electrical Quantities R&D division Metrosert AS Teaduspargi 8, 12618 Tallinn, Estonia	Andrei Pokatilov andrei.pokatilov@metrosert.ee Tel: +372 529 7095	Yes
6.	FYR Macedonia	BoM	Bureau of Metrology	Bureau of Metrology (BoM) Bull. Jane Sandanski 109 a MK-1000 Skopje R., FYR Macedonia	Stanislava Kroneva Petrovska stanislava.kroneva@bom.gov.mk Tel: +389 2 2403 676	Yes
7.	Ireland	NSAI NML	NSAI National Metrology Laboratory	NSAI National Metrology Laboratory Griffith Avenue Extension, Glasnevin, Dublin 11, D11 E527 Ireland.	Oliver POWER Oliver.Power@nsai.ie T: + 353 1 808 2610	No
8.	Kosovo	KMA	Kosovo Metrology Agency	KMA (Kosovo Metrology Agency) Str.”Smajl Hajdaraj" p.n. Lagja Universitetit 10000 Prishtinë, Republika e Kosovës	Musa Misini Musa.Misini@rks-gov.net Tel: +381 38 512 100	No
9.	Lithuania	FTMC	Centre for Physical Sciences and Technology	Centre for Physical Sciences and Technology A. Gostauto str. 11 LT-01108 Vilnius, Lithuania	Andrius Bartasiunas andrius.bartasiunas@ftmc.lt Tel: +370 5 261 80 65	Yes

No	Country	Acronym of Institute	Name of Institute	Shipping Address	Contact Person	ATA Carnet
10.	Montenegro	MBM	Montenegrin Bureau of Metrology	Montenegrin Bureau of Metrology (MBM) Kralja Nikole 2 XM-81000 Podgorica, Montenegro	Rabina Šabotić rabina.sabotic@metrologija.gov.me Tel: +382 20 601 360	Yes
11.	Poland	GUM	Central Office of Measures	Central Office of Measures Glówny Urzad Miar ul. Elektoralna 2 PL-00 950 Warszawa, Poland	Paweł Zawadzki p.zawadzki@gum.gov.pl Tel: +48 22 581 9241	Yes
12.	Portugal	IPQ	Instituto Português da Qualidade	Instituto Português da Qualidade Laboratório Nacional de Metrologia Rua António Gião 2 PT-2829-513 Caparica, Portugal	Luis Ribeiro LRibeiro@ipq.pt Tel: +351 212 948 161	Yes
13.	Romania	INM	National Institute of Metrology	National Institute of Metrology (INM) Sos. Vitan-Bârzesti 11 RO-042122 Bucuresti, Romania	Liliana Cirneanu liliana.cirneanu@inm.ro Tel: +4021 334 50 60 (ext. 153)	Yes
14.	Saudi Arabia	SASO	The Saudi Standards, Metrology and Quality Organization (SASO)	الهيئة السعودية للمواصفات والمقاييس والجودة أمام جامعة الملك سعود -حي المحمدية -الرياض ص.ب 3437 الرياض 11471 المملكة العربية السعودية (مبنى رقم 4 - المركز الوطني للمعايرة) The Saudi Standards, Metrology and Quality Organization (SASO) PO. B 3437 Riyadh- Al Muhammadiyah – in front of King Saud University (Bldg. # 4, NMCC) 11471 Riyadh Kingdom of Saudi Arabia	Eng. Abdullah Alrobaish a.robaish@saso.gov.sa Tel: +966 504104070 Dr. Mamdouh Halawa mamdouh_halawa@yahoo.com Tel: +966 508796538	No
15.	United Arab Emirates (UAE)	QCC EMI	Abu Dhabi Quality and Conformity Council (QCC) Emirates Metrology Institute (EMI)	Emirates Metrology Institute Abu Dhabi Quality and Conformity Council (QCC) CERT Sultan Bin Zayed the First Street Abu Dhabi, UAE	Jon Bartholomew Jon.Bartholomew@qcc.abudhabi.ae Tel: +971 503862676	No
16.	Turkey	UME	TÜBİTAK Ulusal Metroloji Enstitüsü (UME)	TÜBİTAK Ulusal Metroloji Enstitüsü (UME) TÜBİTAK Gebze Yerleşkesi Barış Mah. Dr. Zeki Acar Cad. No:1 41470 Gebze-Kocaeli, TURKEY	Saliha Turhan saliha.turhan@tubitak.gov.tr Tel: +90 262 679 50 00 (Ext. 4201)	Yes

Annex 2: The Checklist Form

Comparison on Calibration of Multimeter

EURAMET Project 1341

☐ Fluke 8508A Reference Multimeter (Serial No: 969656608)

☐ Power cord

☐ 4 wire shorting device

☐ ATA Carnet

Annex 3: The Receipt Form

Comparison on Calibration of Multimeter

EURAMET Project 1341

The received date of transport case	
Was there any serious damage on the transport case?	Yes ☐ No ☐
Was the contents of the transport case (given in Annex 2) completed?	Yes ☐ No ☐ If No, please list missing items:
After inspection, the travelling standard is in working condition?	Yes ☐ No ☐
The travelling standard passed the selftest?	Yes ☐ No ☐
Remarks	

The transport case was received by:

Institute	
Contact Person	
E-mail Address	
Telephone No	

Please send the form to the coordinator of the comparison!

saliha.turhan@tubitak.gov.tr

Annex 4: The Dispatch Form

Comparison on Calibration of Multimeter

EURAMET Project 1341

The travelling standard is in working condition?	Yes ☐	No ☐
The travelling standard passed the selftest?	Yes ☐	No ☐
Is the contents of the transport case (given in Annex 2) completed?	Yes ☐	No ☐
The dispatch date of transport case		
Shipping way (Courier, in hand etc.)		
	Courier Name: Tracking No: Airline: Flight No: Dated:	
Shipping to (Participant Name & Address)		
Remarks		

The transport case was dispatch by:

Institute	
Contact Person	
E-mail Address	
Telephone No	

Please send the form to the next participant and the coordinator of the comparison!

saliha.turhan@tubitak.gov.tr

Annex 5: The Format for Reporting the Results

1. PARTICIPANT INSTITUTE

Institute	
Contact Person	
E-mail	
Address	

2. PERIOD OF MEASUREMENTS

3. AMBIENT CONDITIONS

Temperature : (±) °C

Relative Humidity : (±) % rh

4. THE MEAUREMENT STANDARDS USED

Name	Manufacturer	Model No	Serial No	Traceability

5. MEASUREMENT METHOD

6. MEASUREMENT RESULTS

DC VOLTAGE

Range of 8508A	Nominal Value	Applied Value	Reading of 8508A	Error of 8508A	Uncertainty[1]
200 mV	+ 100 mV				
20 V	+ 10 V				
200 V	+ 100 V				
1000 V	+ 1000 V				

DC CURRENT

Range of 8508A	Nominal Value	Applied Value	Reading of 8508A	Error of 8508A	Uncertainty[1]
200 µA	+ 100 µA				
20 mA	+ 10 mA				
1 A	+ 1 A				

DC RESISTANCE

Range of 8508A	Mode of 8508A	Nominal Value	Applied Value	Reading of 8508A	Error of 8508A	Uncertainty[1]
20 Ω	TrueΩ	10 Ω				
20 kΩ	TrueΩ	10 kΩ				
	TrueΩ Lol	10 kΩ				
2 MΩ	Normal Ω	1 MΩ				

AC VOLTAGE

Range of 8508A	Nominal Value		Applied Voltage	Reading of 8508A	Error of 8508A	Uncertainty[1]
	Voltage	Frequency				
200 mV	100 mV	55 Hz				
	100 mV	1 kHz				
20 V	10 V	55 Hz				
	10 V	1 kHz				
	10 V	100 kHz				
200 V	100 V	55 Hz				
	100 V	1 kHz				

AC CURRENT

Range of 8508A	Nominal Value		Applied Current	Reading of 8508A	Error of 8508A	Uncertainty[1]
	Current	Frequency				
20 mA	10 mA	300 Hz				
	10 mA	1 kHz				
1 A	1 A	300 Hz				
	1 A	1 kHz				

[1] *Expanded uncertainty corresponding to the coverage probability of approximately 95 %.*

7. UNCERTAINTY BUDGET

7.1. DC Voltage

Model Function:

$E_x = f(x_1, x_2, \ldots, x_N)$

Table 1. Uncertainty budget for 100 mV

Quantity X_i	Estimate x_i	Standard Uncertainty $u(x_i)$	Probability Distribution	Sensitivity Coefficient c_i	Uncertainty Contribution $u_i(E_x)$	Degrees of Freedom (DoF) v_i
Error (E_x)		Combined Uncertainty, $u(E_x)$				
		Effective Degrees of Freedom, v_{eff}				
		Coverage Factor, k				
		Expanded Uncertainty, $U(E_x)$				

7.2. DC Current

7.3. DC Resistance

7.4. AC Voltage

7.5. AC Current